Indian Journal of Geo Marine Sciences
Vol. 49 (03), March 2020, pp. 364-372

Seasonal variation of ichthyofauna in trawling grounds off Mangaluru coast, Southwest coast of India

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Received 10 May 2018; revised 24 July 2018

Mangaluru coast, Southwest coast of India has vast aquatic bio-resources and offers considerable scope for marine fisheries development. The present investigation was carried out to assess the ichthyofaunal diversity off Mangaluru coast, Karnataka, India (Lat.12°50'54" N; Long. 74°50'11" E). The data for the study was collected from 160 multiday trawlers operating from Mangaluru fishing harbour during September, 2012 to April, 2013. A total of 97 species belonging to 72 genera, 50 families and 15 orders were recorded. Order Perciformes was the most diversified group having 56 fish species (57.7 %) followed by Clupeiformes 14 fish species (14.4 %), and Tetraodontiformes and Pleuronectiformes with 4 fish species each (4.1 %). The family Carangidae contributed 13.4 per cent of total number of species, followed by Clupeidae (6.2 %) and Engraulidae (5.2 %). *Trichiurus lepturus* contributed 15.42 per cent of total landing followed by *Sardinella longiceps* (12.1 %), *Nemipterus japonicus* (10.7 %), *Decapterus russelli* (9.9 %), *Rastrelliger kanagurta* (9.6 %) and *Nemipterus randalli* (8.4 %). The overall cluster analysis of the Bray-Curtis similarity (hierarchical clustering) shown that maximum similarity (89.7 %) was between March-2013 and April-2013. The study showed that the samples from adjacent months were having more similarity in species composition and abundance. The stress value, which overlying on the MDS plot (0.06), showed greater extent of ordination in the collected samples.

[**Key Words**: Fish assemblage, Fishing, Mangaluru coast, Southwest coast of India, Trawling]

Introduction

India is one among the 17 mega biodiversity countries in the world. With only 2.5 % of the land area, India accounts for 7.8 % of the recorded species of the world[1]. Marine fish stocks in many parts of the world have been exploited indiscrimately[2] adversely affecting the bio-diversity. Fishing has a great role in bringing about changes in the marine ecosystem through removal of fishes and benthic communities thereby causing lethal environmental effects[3,4]. The effect of fishing on the marine ecosystem has come under increasing scarcity in recent years. Trawling, in particular, is the focus of attention because of the gear's low selectivity[5] and impacts on the sea floor. In recent years there has been increasing concern over the impact of fishing on continental shelf ecosystems[6]. Fishing has both direct (e.g. removal of species) and indirect (e.g. habitat modification, changes in prey or predator densities) impact on ecosystem. The physical impacts of demersal fishing methods on benthic habitats have been well documented[7-9]. Hence, the present investigation was mainly focused on seasonal variation of fish assemblages associated with the trawl catches along Mangaluru coast, Southwest coast of India.

Materials and Methods

Site selection, sampling methods and data collection

Mangaluru fishing harbour is one of the important landing centres along Karnataka coast (Fig. 1). For the present study, data was collected from the 160 multiday trawlers (n = 160) operating from Mangaluru fishing harbour during September-2012 to April-2013. The sampling units (trawlers) were selected employing the stratified random sampling design developed by CMFRI[10]. For the entire duration of sampling, data was collected at fortnightly interval. However, for ease of analysis and interpretation, fortnightly datasets for each month were pooled together and processed for further analysis. Species wise catch statistics from twenty (20) sampling units were recorded every fortnightly by observation in terms of number of baskets or crates or weight in kilograms landed. Species-wise average holding

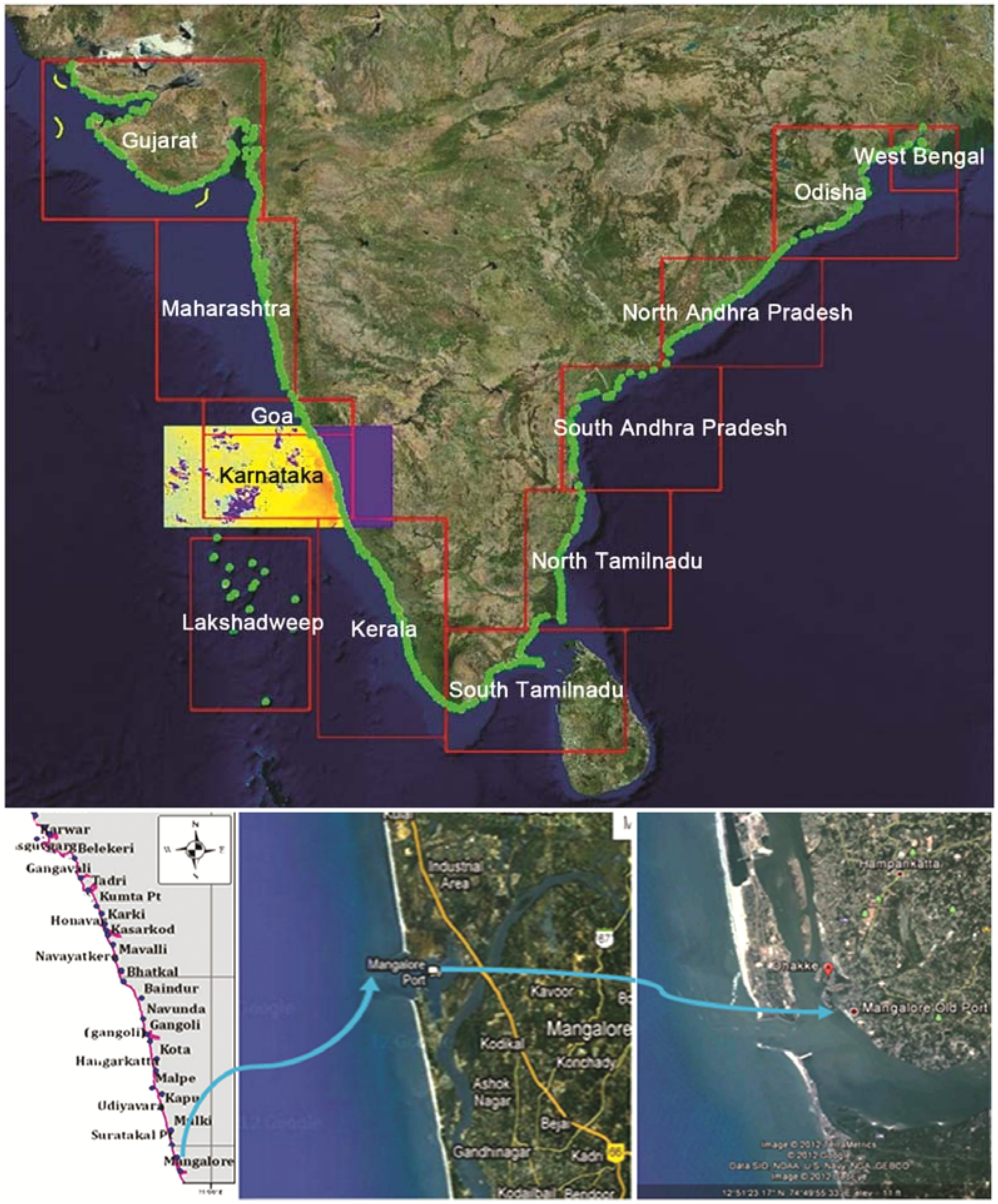

Fig. 1 — Mangaluru fish landing center, Karnataka, India (Jetty) (Lat.12°50'54" N; Long. 74°50'11" E)

capacity of basket and crate was estimated once and same average was used to convert the number of baskets landed into quantity in kilograms.

Identification of fish species

Identification of fishes was done using fresh or preserved specimens. They were identified by following standard taxonomic keys FAO Identification Sheets, ITIS (Integrated Taxonomic Information System) Standard Report (http://www.itis.gov), and FishBase (http://fishbase.org). The collected fish were identified up to species level.

Multivariate analysis

Multivariate analysis of the data was used to determine differences in community structure between samples in space. The data were square root transformed before the analysis for cluster analysis. The similarity in species composition based on the abundance was studied by calculating the Bray-Curtis coefficient (Cluster analysis). This is the first step for calculation of similarity of the biological communities between any pair of sample. The computation of matrices of similarities between different pair of sample is based on Bray-Curtis similarities measure.

Non-metric Multi Dimensional Scaling (MDS) is used to understand the interrelationship between the samples in a map. The stress value is indicating the goodness of the fit. In non-metric multidimensional scaling (MDS), the Bray–Curtis similarity was used to construct a map in which those having more similarity were placed near and samples having lower similarity far away. The goodness of fit of the MDS was found by calculating the stress value using the formula.

The variation in taxonomic distinctness value calculated for each sample was superimposed on the funnel to find out the deviation from the normal distribution (within the 95 % confidence limit or not). Making use of the abundance table and the aggregation table giving information regarding the taxonomy of the species, the funnel and ellipse plots were drawn. Moreover, a funnel drawn with variation in taxonomic distinctness, tests the variance between the samples. All analyses including fish diversity structure was analyzed by multivariate statistical techniques using the PRIMER-E (Version 6) analytical package developed by Plymouth Marine Laboratory, U.K[11,12].

Results and Discussion

A total of 97 species belonging to 72 genera, 50 families and 15 orders were collected during the present study (Table 1) which was commonly found in the region. Purusothaman *et al.*,[13] recorded 123 species of fishes belonging to 13 orders, 49 families and 82 genera along the southeast coast of India. Almost similar result was reported by Sirajudheen and BijuKumar[14], they recorded 138 species belonging to 14 orders 67 families and 108 genera in trawl catch of the Neendakara fishing harbour of Kerala. Ramu *et al*. (2015) recorded 95 species belonging to 42 families and 59 genera along the coastal line of Nagapattinam.

Table 1 — Documented fish diversity of trawling grounds along Mangaluru coast, Karnataka, India

		Class: Elasmobranchii
Order	Family	Species
Carcharhiniformes	Carcharhinidae	*Carcharhinus limbatus* (Muller & Henle, 1839)
		Galeocerdo cuvier (Peron & Lesueur, 1822)
	Sphyrnidae	*Sphyrna lewini* (Griffith & Smith, 1834)
Myliobatiformes	Dasyatidae	*Himantura gerrardi* (Gray, 1851)
		Himantura bleekeri (Blyth, 1860)
Rajiformes	Rhinobatidae	*Rhina ancylostoma* (Bloch & Schneider, 1801)
		Glaucostegus granulatus (Cuvier, 1829)
		Class: Actinopterygii
Anguilliformes	Muraenesocidae	*Muraenesox cinereus* (Forsskål, 1775)
Aulopiformes	Synodontidae	*Saurida tumbil* (Bloch, 1795)
		Saurida undosquamis (Richardson, 1848)
Beloniformes	Hemiramphidae	*Hyporhamphus limbatus* (Valenciennes, 1847)
Clupeiformes	Chirocentridae	*Chirocentrus dorab* (Forsskål, 1775)
	Clupeidae	*Anodontostoma chacunda* (Hamilton, 1822)
		Escualosa thoracata (Valenciennes, 1847)
		Sardinella albella (Valenciennes, 1847)
		Sardinella fimbriata (Valenciennes, 1847)
		Sardinella gibbosa (Bleeker, 1849)
		Sardinella longiceps (Valenciennes, 1847)
	Dussumieriidae	*Dussumieria acuta* (Valenciennes, 1847)
	Engraulidae	*Encrasicholina devisi* (Whitley, 1940)
		Stolephorus commersonnii (Lacepède, 1803)
		Stolephorus indicus (van Hasselt, 1823)
		Stolephorus insularis (Hardenberg, 1933)
		Stolephorus waitei (Jordan & Seale, 1926)
	Pristigasteridae	*Ilisha megaloptera* (Swainson, 1839)
Elopiformes	Megalopidae	*Megalops cyprinoides* (Broussonet, 1782)
Lophiiformes	Lophiidae	*Lophiomus setigerus* (Vahl, 1797)

(*Contd.*)

Table 1 — Documented fish diversity of trawling grounds along Mangaluru coast, Karnataka, India (*Contd.*)

		Class: Actinopterygii
Perciformes	Carangidae	*Alectis ciliaris* (Bloch, 1787)
		Alectis indicus (Rüppell, 1830)
		Alepes djedaba (Forsskål, 1775)
		Atule mate (Cuvier, 1833)
		Carangoides malabaricus (Bloch & Schneider, 1801)
		Decapterus russelli (Rüppell, 1830)
		Elagatis bipinnulata (Quoy & Gaimard, 1825)
		Megalaspis cordyla (Linnaeus, 1758)
		Parastromateus niger (Bloch, 1795)
		Scomberoides tala (Cuvier, 1832)
		Seriolina nigrofasciata (Rüppell, 1829)
		Trachinotus blochii (Lacepède, 1801)
		Trachinotus mookalee (Cuvier, 1832)
	Coryphaenidae	*Coryphaena hippurus* (Linnaeus, 1758)
	Chaetodontidae	*Heniochus acuminatus* (Linnaeus, 1758)
	Drepaneidae	*Drepane punctata* (Linnaeus, 1758)
	Ephippidae	*Platax orbicularis* (Forsskål, 1775)
	Gerreidae	*Gerres filamentosus* (Cuvier, 1829)
	Lactariidae	*Lactarius lactarius* (Bloch & Schneider, 1801)
	Leiognathidae	*Photopectoralis bindus* (Valenciennes, 1835)
		Secutor insidiator (Bloch, 1787)
	Lobotidae	*Lobotes surinamensis* (Bloch, 1790)
	Lutjanidae	*Lutjanus argentimaculatus* (Forsskål, 1775)
		Lutjanus russellii (Bleeker, 1849)
		Pinjalo pinjalo (Bleeker, 1850)
	Menidae	*Mene maculata* (Bloch & Schneider, 1801)
	Mullidae	*Upeneus vittatus* (Forsskål, 1775)
	Nemipteridae	*Nemipterus japonicus* (Bloch, 1791)
		Nemipterus randalli (Russell, 1986)
		Parascolopsis aspinosa (Rao & Rao, 1981)
	Pinguipedidae	*Parapercis alboguttata* (Günther, 1872)
	Polynemidae	*Eleutheronema tetradactylum* (Shaw, 1804)
	Priacanthidae	*Priacanthus hamrur* (Forsskål, 1775)
	Rachycentridae	*Rachycentron canadum* (Linnaeus, 1766)
	Sciaenidae	*Johnius glaucus* (Day, 1876)
		Johnius dussumieri (Cuvier, 1830)
		Nibea maculata (Bloch & Schneider, 1801)
		Otolithes ruber (Bloch & Schneider, 1801)
		Otolithes cuvieri (Trewavas, 1974)
	Scombridae	*Rastrelliger kanagurta* (Cuvier, 1816)
		Scomberomorus commerson (Lacepède, 1800)
		Scomberomorus guttatus (Bloch & Schneider, 1801)
	Serranidae	*Epinephelus bleekeri* (Vaillant, 1878)
		Epinephelus diacanthus (Valenciennes, 1828)
		Epinephelus epistictus (Temminck & Schlegel, 1842)
		Epinephelus latifasciatus (Temminck & Schlegel, 1842)
	Sparidae	*Acanthopagrus berda* (Forsskål, 1775)
	Sphyraenidae	*Sphyraena barracuda* (Edwards, 1771)
		Sphyraena jello (Cuvier, 1829)
		Sphyraena obtusata (Cuvier, 1829)

(*Contd.*)

Table 1 — Documented fish diversity of trawling grounds along Mangaluru coast, Karnataka, India (*Contd.*)

		Class: Actinopterygii
	Stromateidae	*Pampus chinensis* (Euphrasen, 1788)
		Pampus argenteus (Euphrasen, 1788)
	Terapontidae	*Terapon jarbua* (Forsskål, 1775)
		Terapon puta (Cuvier, 1829)
		Terapon theraps (Cuvier, 1829)
	Trichiuridae	*Trichiurus lepturus* (Linnaeus, 1758
Pleuronectiformes	Cynoglossidae	*Cynoglossus bilineatus* (Lacepède, 1802)
		Cynoglossus puncticeps (Richardson, 1846)
		Cynoglossus macrostomus (Norman, 1928
	Psettodidae	*Psettodes erumei* (Bloch & Schneider, 1801)
Scorpaeniformes	Dactylopteridae	*Dactyloptena peterseni* (Nyström, 1887)
	Platycephalidae	*Grammoplites suppositus* (Troschel, 1840)
	Scorpaenidae	*Pterois russelii* (Bennett, 1831)
Siluriformes	Ariidae	*Netuma thalassina* (Rüppell, 1837)
	Plotosidae	*Plotosus canius* (Hamilton, 1822)
Syngnathiformes	Fistulariidae	*Fistularia petimba* (Lacepède, 1803)
Tetraodontiformes	Balistidae	*Abalistes stellaris* (Bloch & Schneider, 1801)
		Odonus niger (Rüppell, 1836)
	Monacanthidae	*Aluterus monoceros* (Linnaeus, 1758)
	Tetraodontidae	*Lagocephalus inermis* (Temminck & Schlegel, 1850)

The order Perciformes contributed 57.73 per cent of total number of species, followed by Clupeiformes (14.4 %), Tetraodontiformes and Pleuronectiformes, 4 fish species each (4.1 %) whereas other orders contributed less than 4 per cent each. Family Carangidae contributed 13.40 per cent of total number of species, followed by Clupeidae (6.1 %), Engraulidae (5.1 %), Sciaenidae (5.1 %), Serranidae (4.1 %), Lutjanidae, Nemipteridae, Scombridae, Sphyraenidae, Terapontidae and Cynoglossidae (3 % each) to the total fish species, whereas other families contributed less than 2 per cent each (Fig. 2).

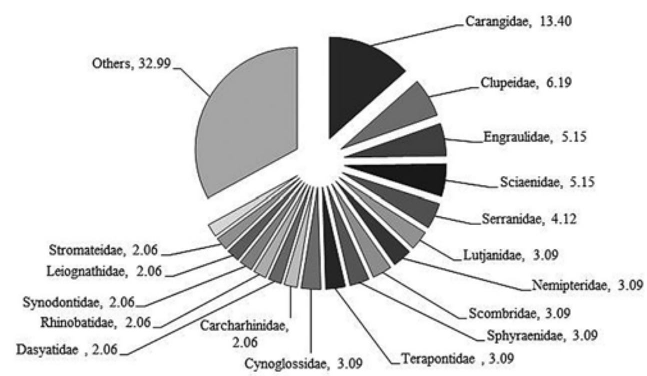

Fig. 2 — Diagrammatic representation of the % contribution of each family

Seasonal variation and species composition

Trichiurus lepturus contributed 15.44 per cent of total landings followed by *Sardinella longiceps* (12.11 %), *Nemipterus japonicus* (10.73 %), *Decapterus russelli* (9.94 %), *Rastrelliger kanagurta* (9.57 %), *Nemipterus randalli* (8.37 %), *Dussumieria acuta* (5.42 %), *Epinephelus diacanthus* (4.48 %), *Lagocephalus inermis* (4.19 %), *Megalaspis cordyla* (3.79 %), *Saurida tumbil* (3.20 %) and *Cynoglossus macrostomus* (1.04 %), whereas other species contribution was less than one per cent. In the total landings, other species contributed 11.74 per cent (Fig. 3). Kuriakose *et al.*,[15] reported that marine fish landings during 2010 has been on the rise with marked increase in catches of the five major resources *viz*. oil sardine, mackerel and ribbonfish. Oil sardine

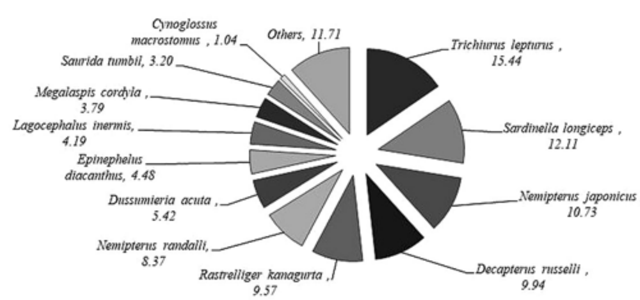

Fig. 3 — Diagrammatic representation of % biomass contribution of each species

and mackerel, together account for about 50 % of the marine fish landings in the south-west region. According to Central Marine Fisheries Research Institute Annual Report 2010-11, the oil sardine, mackerel, threadfin breams, carangids, ribbonfish and lizard fishes contributed 19.4 %, 16.5 %, 8.3 %, 6.6 %, 5.2 %, 5.0 %, respectively. In the present study, the species *Trichiurus lepturus* contributed 15.44 % of total landing followed by *Sardinella longiceps* (12.11 %) and *Nemipterus japonicus* (10.73 %). Naomi *et al.,*[16] had reported on the trawl fishery of southern Kerala where the major species recorded were *Nemipterus randalli* (16.8 %) followed by Ribbon fish (*Trichiurus lepturus*) (14.3 %) and *Decapterus russelli* (14 %). A similar catch composition was recorded during the present study. The result of this study also highlights the biodiversity along the Mangaluru coast. Several authors have studied the catch composition of trawlers[15-21]. Sehara and Karbhari[22] studied catch composition along the Saurashtra and Gujarat and reported 15.8 % prawn landings which were followed by ribbonfish (12.3 %).

In the present study, *Trichiurus lepturus* was most dominant species and contributed maximum catch in the month of October, November, February, March and April to the total landings. *Sardinella longiceps* contributed maximum catch in the month of December and January and *Nemipterus japonicus* contributed maximum catch in the month of September during the study period. Pravin *et al.* (1998) have also reported ribbonfish as major constituents of catch at Veraval.

In the present study, the maximum landings were recorded during the month of October with 14.43 % share to total fish production, which declined to 12.80 % in the month of November and 11.19 % in the month of December. Thereafter, percentage landing values increased to 11.83 % in January 2013 and 13.30 % in the month of February 2013 and again declined to 11.30 % in the month of March 2013. Naomi *et al.,*[16] reported that finfishes were abundant during September-October (29.3 %) and April-May (29.3 %). Kuriakose *et al.,*[15] also reported the peak season for trawl landings along the south-west coast was during October-December and contributed 39 % of the total catch. In the present study, the month of October 2012 recorded maximum landings and was found to be more productive as reported by Naomi *et al.*[16] and Kuriakose *et al.,*[15]. Borkar and Komapany[20] also studied temporal variation in the icthyofaunal diversity of Goa coast and they reported that species richness of marine fish landings was high in post-monsoon followed by pre-monsoon and monsoon. Similar results were observed in the present study as well.

Maliel[24] observed indirect relationship between trawl catch and bottom water temperature along the west coast of India. Benakappa *et al.,*[25] noticed good landings of oil sardine and Indian mackerel along Mukka-Kaup region of South Kanara coast. Earlier a few studies have been conducted on the influence of some oceanographic conditions on the pelagic fishes[25,26], coastal current patterns[27] and bottom water currents and other hydrographic parameters[28] along South Kanara Coast. Krishnakumar and Bhat[29] and Kumar e*t al.,*[30] studied seasonal and inter-annual variations of oceanographic conditions off Mangaluru coast (Karnataka, India) in the Malabar upwelling system during 1995–2004 and their influence on the pelagic fishery. They observed that temperature is one of the important factors controlling the sea's physical and chemical processes which affect catches. Coastal upwelling occurred during July–September with a peak in August resulting in high nutrient concentrations and biological productivity along the coast. Nearly 70 % of the pelagic fish catch, dominated by oil sardine and mackerel, was obtained during September–December, during or immediately after the upwelling season. Similar results were obtained in the present study where the fish landings were high during the month of October (post-monsoon season). During the upwelling period the coastal waters become nutrient rich encouraging high plankton biomass and providing favorable condition for fish stock. This may be one of the possible reasons for high catches during post-monsoon season.

Non-metric multi-dimensional scaling (MDS)

The results of the present study showed that samples from adjacent months have more similarity in species composition and abundance than samples separated over a period. There was similarity in the species composition of samples for the same season as revealed by MDS plot (Fig. 4). Samples collected during pre-monsoon and post-monsoon period formed two distinct groups showing a greater degree of similarity in the species composition (80 %) within the groups and the samples collected during monsoon showed 60 % similarity with the two segregated samples groups from pre and post monsoon. The stress value, which was overlying on the MDS plot (0.06), showed greater degree of ordination in the collected samples (Fig. 5). The trend observed in cluster analysis was quiet evident here. The stress values found in MDS configurations were low (< 0.1) suggesting good representation of interrelationship between all months. As a rough guide to efficiency, a stress value S > 0.5 is probably random, 0.5> S> 0.25 is a poor result, 0.25> S> 0.1 is a satisfactory and S < 0.1 is a good result[31]. In the present study the stress value obtained in MDS configuration was low (< 0.1) indicating good representation of interrelationship between all months and seasons. Similar results were reported by Khan *et al.*,[31]; Murugesan and Purusothaman[21] ; and Thivakaran and Kundu[32].

Cluster analysis

In the present study, hierarchical cluster analysis technique was used to see the similarity in species composition and abundance during the study period (Fig. 5). The results of the hierarchical clustering were derived by using the group average linking

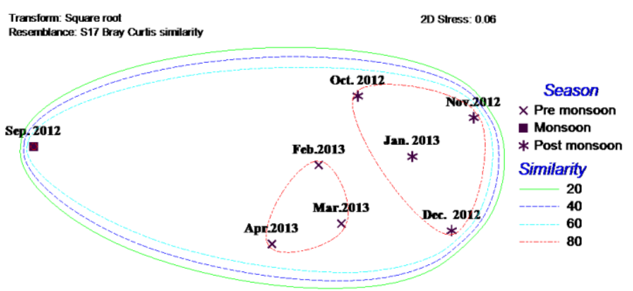

Fig. 4 — MDS plot showing various similarity levels showed that samples from adjacent months have more similarity in species composition and abundance than samples separated over a period.

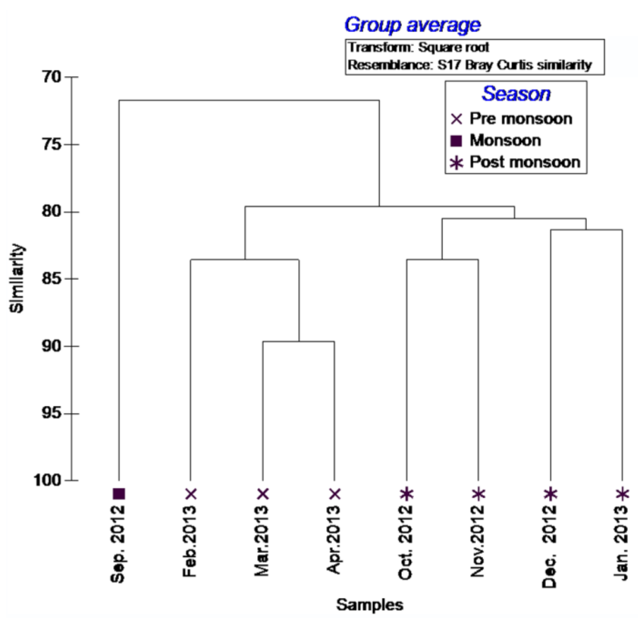

Fig. 5 — Hierarchical clustering during the study period (Month wise) [The dendrogram drawn clearly revealed the separate grouping similarity in species composition and abundance of different months and seasons]

between months during the study period. From the overall cluster analysis, it was observed that the maximum similarity in species composition and abundance (89.65 %) was observed between the month of March 2013 and April 2013 and minimum interrelationship was between September 2012 and November 2012 (67.43 %) (Fig. 5). The dendrogram drawn clearly revealed the separate grouping similarity in species composition and abundance of different months. The hierarchical clustering by using the group average linking between the species during the study period was plotted. *Decapterus russelli* and *Rastrelliger kanagurta* indicated the dominant group assemblage in marine water in Mangaluru coast which is also supported by Naomi *et al.*,[16]; Anon[33] and Dineshbabu *et al.*,[22]. The hierarchical cluster was also plotted to see the similarity between the season and the result showed that maximum similarity between post-monsoon and pre-monsoon. Similar results were reported by Borkar and Komapany[20] in their study.

Taxonomic distinctness tests (TAXDTEST)

In the ellipse plot (Figs. 6 & 7) drawn combining the average taxonomic distinctness and variation in taxonomic distinctness values, statistically significant departure of all months can be seen clearly. The ellipse plot also clearly showed that, fitted at 95 % probability contours of average taxonomic distinctness (delta+) and variation in taxonomic distinctness (lambda+) showing statistically no deviation during the study period and all the values higher diversity fell within the confidence funnel. Similar results were reported by Khan *et al.*,[31] in their study.

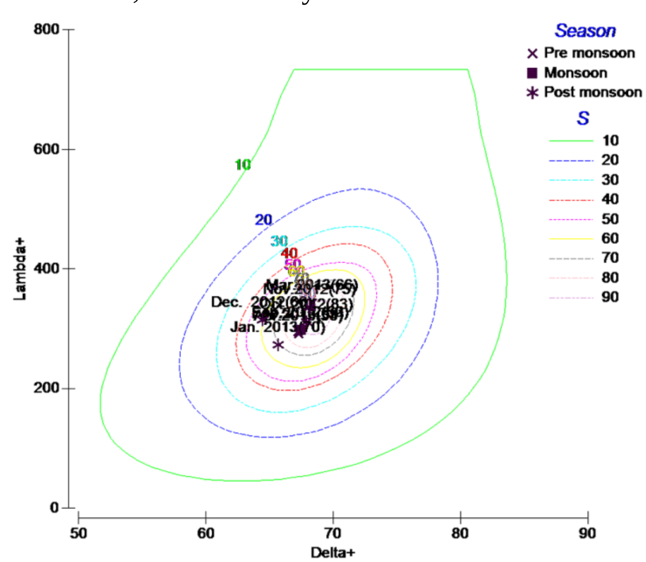

Fig. 6 — Ellipse plot (fitted 95 % probability)

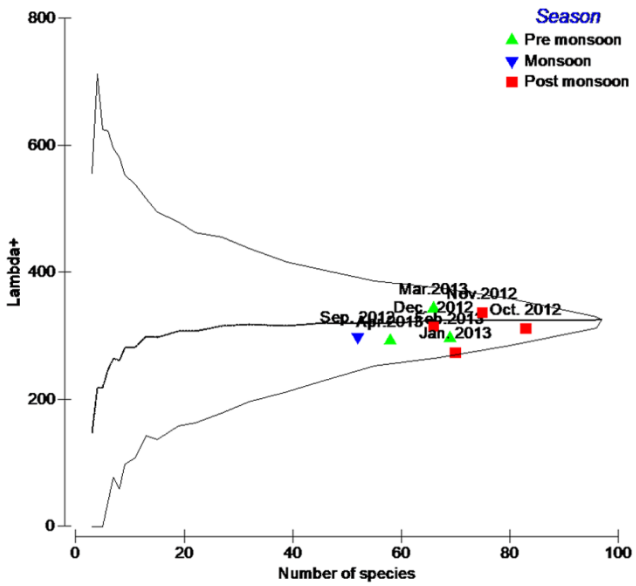

Fig. 7 — The 95 % confidence funnel for variation in taxonomic distinctness (lambda+)

Conclusion

It is estimated that 75 % of the world fishery resources are either fully fished, overfished or depleted[34]. This study facilitates understanding of the community patterns of the fishes at species levels in a dynamic marine environment and also provides information in formulating an effective management system for its conservation. The loss of diversity needs to be checked by formulating stringent regulation for the maintenance of habitat as well as rejuvenation of the stocks.

Acknowledgements

This manuscript is a part of M.F.Sc. Thesis of the first author approved by the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka. The authors wish to express their sincere gratitude to Dean, College of Fisheries, Mangaluru for providing necessary facilities, which created a better environment for academic activities and research at the campus.

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